[0001]   OUTER LOOP TRANSMIT POWER CONTROL
USING CHANNEL-ADAPTIVE PROCESSING

[0002]   Cross Reference to Related Applications

[0003]   The application is a continuation of 10/036,118 filed on December 26, 2001 which claims priority from Provisional Patent Application No. 60/323,541, filed September 20, 2001.

[0004]   BACKGROUND

[0005]   The present invention relates to spread spectrum time division duplex (TDD) communication systems. More particularly, the present invention relates to a system and method for controlling outer loop transmission power within TDD communication systems.

[0006]   Spread spectrum TDD systems carry multiple communications over the same spectrum. The multiple signals are distinguished by their respective chip code sequences (codes). Referring to Figure 1, TDD systems use repeating frames 34 divided into a number of time slots 37_1-37_n, such as fifteen time slots. In such systems, a communication is sent in a selected time slot out of the plurality of time slots 37_1-37_n using selected codes. Accordingly, one frame 34 is capable of carrying multiple communications distinguished by both time slot and code. The combination of a single code in a single time slot is referred to as a physical channel. Based on the bandwidth required to support a communication, one or multiple physical channels are assigned to that communication.

[0007]   Most TDD systems adaptively control transmission power levels. In a TDD system, many communications may share the same time slot and spectrum. While user equipment (UE) 22 is receiving a downlink transmission from a base station, all the other communications using the same time slot and spectrum cause

interference to the specific communication. Increasing the transmission power level of one communication degrades the signal quality of all other communications within that time slot and spectrum. However, reducing the transmission power level too far results in undesirable signal to noise ratios (SNRs) and bit error rates (BERs) at the receivers. To maintain both the signal quality of communications and low transmission power levels, transmission power control is used.

[0008]   The purpose of power control is to use the minimum power required to allow each transport channel (TrCH) to operate with the Block Error Rate (BLER) no higher than its required level. The standard approach to TDD downlink power control is a combination of inner and outer loop control. In this standard solution, the UE transmits physical layer transmit power control (TPC) commands to adjust the base station transmission power.

[0009]   A base station sends a transmission to a particular UE. Upon receipt, the UE measures the signal interference ratio (SIR) in all time slots and compares this measured value to a targetSIR. This target SIR is generated from the BLER signaled from the base station. As a result of a comparison between the measured SIR value with the target SIR the UE transmits a TPC command to the base station. The standard approach provides for a TPC command per coded composite transport channel (CCTrCH). The CCTrCH is a physical channel which comprises the combined units of data for transmission over the radio interface to and from the UE or base station. This TPC command indicates to the base station to adjust the transmission power level of the downlink communication. The base station, which is set at an initial transmission power level, receives the TPC command and adjusts the transmit power level in all time slots associated with the CCTrCH in unison. The inner loop power control algorithm controls transmit power to maintain the received SIR as close as possible to a target SIR by monitoring the SIR measurements of the data. The outer loop power control algorithm controls the target SIR to maintain the received quality BLER as close as possible to a target quality BLER based on the Cyclic Redundancy Code (CRC)

check of the data. The output from the outer loop power control is a new target SIR per CCTrCH used for the inner loop power control.

[0010]   There are four main error sources in transmission power control: 1) channel error; 2) systematic error; 3) random measurement error; and 4) coded composite transport channel (CCTrCH) processing error. The systematic error and the random measurement error are corrected reasonably by the inner loop power control by monitoring the SIR measurements. The CCTrCH processing error is corrected by either the outer loop power control or the inner loop power control by using relative SIR measurements among the codes. The channel error is related to unknown time-varying channel conditions.

[0011]   In power control systems, the outer loop power control algorithm would set a target SIR for each CCTrCH based on the required target BLER, assuming a most plausible channel condition. Therefore, the mismatch between the target BLER and the mapped target SIR varies depending on the actual channel condition, and it is especially large at very low BLER. Since the outer loop power control depends on the CRC check, it often takes a long time to converge to the required target SIR for the low BLER.

[0012]   Accordingly, there is a need for outer loop power control which determines the actual channel conditions so that a proper value for the target SIRs is used.

[0013]   SUMMARY

[0014]   The present invention is a system and method which controls outer loop transmit power for transmission power of an uplink/downlink communication in a wireless communication system. The system receives a communication from a base station and determines an error rate on the received communication. The system then distinguishes between static and dynamic channels, produces a static adjustment value, and characterizes the dynamic channels to generate a dynamic adjustment value. The target power level is then adjusted by the static and dynamic adjustment

-3-

values, setting the transmission power level.

[0015]　　　　　　　BRIEF DESCRIPTION OF THE DRAWINGS

[0016]　　　　Figure 1 illustrates time slots in repeating frames of a TDD system.

[0017]　　　　Figure 2 illustrates a simplified wireless TDD system.

[0018]　　　　Figures 3A and 3B illustrate block diagrams of a UE and base station, respectively.

[0019]　　　　Figure 4 is a graphical illustration of the mapping of the BLER with a target SIR value.

[0020]　　　　Figure 5 is an illustration of the jump algorithm in accordance with the present invention.

[0021]　　　　Figures 6A and 6B are block diagrams of the split sliding windows for the first and second filter processes.

[0022]　　　　Figure 7 is a flow diagram of channel discrimination filtering for use in downlink power control.

[0023]　　　　Figure 8 is a flow diagram of fading channel filtering for use in downlink power control.

[0024]　　　　Figure 9 is a flow diagram of a channel-adaptive downlink outer-loop power control algorithm of the present invention.

[0025]　　　　DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026]　　　　The preferred embodiments will be described with reference to the drawing figures where like numerals represent like elements throughout.

[0027]　　　　Figure 2 illustrates a simplified wireless spread spectrum code division multiple access (CDMA) or time division duplex (TDD) communication system 18. The system 18 comprises a plurality of node Bs 26, 32, 34, a plurality of radio network controllers (RNC), 36, 38, 40, a plurality of user equipments (UEs) 20, 22, 24 and a core network 46. The plurality of node Bs 26, 32, 34 are connected to a plurality RNCs 36, 38, 40, which are, in turn, connected to the core network 46. Each Node B, such as

Node B 26, communicates with its associated UEs 20-24. The Node B 26 has a single site controller (SC) associated with either a single base station 30_1, or multiple base stations $30_1...30_n$.

[0028]   Although the present invention is intended to work with one or more UEs, Node Bs and RNCs, for simplicity of explanation, reference will be made hereinafter to the operation of a single UE in conjunction with its associated Node B and RNC.

[0029]   Referring to Figure 3A, the UE 22 comprises an antenna 78, an isolator or switch 66, a modulator 64, a demodulator 68, a channel estimation device 70, data estimation device 72, a transmit power calculation device 76, an interference measurement device 74, an error detection device 112, a processor 111, a target adjustment generator 114, a reference channel data generator 56, a data generator 50, and two spreading and training sequence insertion devices 52, 58.

[0030]   The UE 22 receives various radio frequency (RF) signals including communications from the base station 30_1 over the wireless radio channel using an antenna 78, or alternatively an antenna array. The received signals are passed through a T/R switch 66 to a demodulator 68 to produce a baseband signal. The baseband signal is processed, such as by a channel estimation device 70 and a data estimation device 72, in the time slots and with the appropriate codes assigned to the UE's 22 communication. The channel estimation device 70 commonly uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses. The channel information is used by the data estimation device 72, the interference measurement device 74 and the transmit power calculation device 76. The data estimation device 72 recovers data from the channel by estimating soft symbols using the channel information.

[0031]   Prior to transmission of the communication from the base station 30_1, the data signal of the communication is error encoded using an error detection/correction encoder 110. The error encoding scheme is typically a CRC followed by a forward error correction encoding, although other types of error encoding schemes may be used. As

those skilled in the art know, the data is typically interleaved over all of the time slots and all codes.

[0032]   In accordance with the preferred embodiment of the present invention, downlink outer loop power control is conducted using a channel adaptive downlink outer loop power control, described hereafter. Using the soft symbols produced by the data estimation device 72, the error detection device 112 detects the target BLER sent from the base station 30_1. Given the target BLER, an initial target SIR_{Target} is generated by mapping the target BLER, using an assumed plausible channel condition, to a SIR value associated with the channel condition. A graphical example of this mapping is illustrated in Figure 4. The lines on this graph are exemplary propagation conditions, wherein the AWGN channel is the static channel for additive white Gaussian noise, and case 1 through case 4 are fading channels with different multipaths.

[0033]   As shown in Figure 4, at a required BLER, for example 0.01 for a case 1 fading channel, a predetermined transmission power can be determined. In the above example, the transmission power is approximately 4.5dB, from which a target SIR is calculated. It is also shown in Figure 4 that the SIR_{Target} at BLER of 0.01 for the case 1 fading channel requires more than 5dB over the SIR_{Target} for the case 2 fading channel. Accordingly, it will take longer to converge to the required SIR_{Target} for a low BLER when assuming the case 1 fading channel and trying to get to the SIR_{Target} for a case 2 fading channel.

[0034]   In order to get from the SIR for the case 1 channel, the assumed channel, for example, to the required SIR for the case 2 channel, the actual channel for example, a jump algorithm is utilized by the processor 111. Initially, the parameters of the jump algorithm SIR_step_down, SIR_step_up are determined using the target BLER in accordance with the following equations:

$$SIR\_step\_down = SIR\_step\_size * target\_BLER \qquad \text{Equation 1}$$

$$SIR\_step\_up = SIR\_step\_size - SIR\_step\_down; \qquad \text{Equation 2}$$

where SIR_step_size is any predetermined value, preferably a value between 0.3 dB and 0.5 dB. As the error detection device 112 detects an error in a Transmission Time Interval (TTI), a SIR_{Target} value is updated by the processor 111 in accordance with Equation 3:

$$SIR_{Target}\ (K) = SIR_{Target}\ (K\text{-}1) + SIR\_step\_up\ (dB) \qquad \text{Equation 3}$$

where K is the number of the TTI. If the error detection device 112 does not detect an error in the TTI, the SIR_{Target} is updated in accordance with Equation 4:

$$SIR_{Target}\ (K) = SIR_{Target}\ (K\text{-}1) \text{-} SIR\_step\_down\ (dB) \qquad \text{Equation 4}$$

[0035]   Also, each time a determination is made by the error detector device 112 whether an error is present in a TTI, a step_up counter or step_down counter is incremented; the step_up counter being incremented each time an error is detected; the step_down counter being incremented otherwise. A graphical representation of the jump algorithm used by the processor 111 to set a target SIR is illustrated in Figure 5. Again, Figure 5 illustrates that for communications where the assumed channel condition differs greatly from the actual channel condition, the convergence from an assumed target SIR to an actual SIR may take a long time.

[0036]   Accordingly, the processor 111 then conducts a channel-adaptive filtering process to further adjust the SIR_{Target}. The channel adaptive filtering process includes two (2) filter processes. The first filter process distinguishes the static and dynamic (or fading) channels, and the second filter process characterizes the dynamic channel conditions. These filter processes are conducted sequentially, (i.e. the second after the first), with one another to produce the necessary adjustments to the SIR_{Target} in accordance with actual channel conditions.

[0037]   Both of the filter processes perform their respective filter processing using a split sliding window 600, 610. Diagrams of the split sliding windows 600, 610 are shown in Figures 6A and 6B, respectively. The split sliding windows 600, 610 comprise a left side window (LW), a variable gap (GW) and a right side window (RW). Each of the respective windows may be any length in size; the length representing the number of values, observations O_1, O_2, to be determined for each of respective windows LW,

RW. GW represents a transition period of channel conditions, which improves the detection of changing channel conditions. For example, if the left side window LW was set to a length of 2, the LW would comprise two observations of the respective sliding windows 600, 610.

[0038]   Each of the respective sliding windows 600, 610 observations' O_1, O_2 are generated each observation period OP_1, OP_2 being any number of time segments within the received communication. For example, the first filter process sliding window 600 may have an observation period OP_1 of 100 ms, where one (1) time segment equals 10 ms. Accordingly, one observation O_1 is made every ten (10) time segments. This is the case for the second filter process sliding window 610 as well. It should be noted, though, that the observation periods OP_1, OP_2 of the filter processes may be different. The sliding window moves one step forward per observation period OP_1, OP_2 and the each of the filtering processes discriminates channel conditions between RW and LW. The values observed/measured O_1, O_2 within RW and LW are utilized by the filtering processes to generate a SIR adjustment value.

[0039]   The algorithm characterizes the channel condition based on the power of the strongest path (P_0) for static/dynamic channel detection in the first filter process and the power ratio of P_1/P_0 (dB) for fading channels, where P_1 is the power of the second strongest path. P_0 is sampled once per observation period OP_1 for the first filter process and $P1/P_0$ (dB), for the second filter process, are averaged once per observation period OP_2 for the second filter process. Each observation O_1, O_2 is stored in the memory to perform filtering by the split sliding windows 600, 610.

[0040]   As stated, the first filtering process 700 distinguishes the static (i.e., path of line of sight) and dynamic channels (i.e. fading multipath), determining whether there is a transition between a dynamic channel and a static channel. Figure 7 is a flow diagram of the first filtering process 700 in accordance with the preferred embodiment of the present invention. The distinguishing of the static and dynamic channels is conducted using the detected peak power of a predetermined observation period OP_1.

[0041]   As explained above, the first filtering process utilizes the split sliding window, as shown in Figure 6A, to generate a static adjustment value. Again, the LW and RW can be of any predetermined length. The GW initially is set to one (1) (Step 702) and is increased by one (1) each iteration, to be disclosed hereinafter. The GW, though, has a preset limitation as to how big it can be, for example, 2 or 3.

[0042]   The processor 111 utilizes the step_up and step_down counts generated in the aforementioned jump algorithm, as well as, the determined power(s) of the strongest path in the LW and RW to calculate the static adjustment value. The first filter process is run after the LW and the RW are filled in with observed/measured peak powers. Accordingly, if the sliding window size was 7, (RW equal 3, LW equals 3 and GW equals 1), 7 observations O_1 would have to be observed before the first filter process generates a static adjustment value.

[0043]   The static adjustment value is calculated in accordance with the following. The mean of the peak values of each observation in the LW and RW and the Δ mean of the peak values are calculated (Step 703) in accordance with Equations 5, 6 and 7 below:

$$mean\_peak_{RW} = \frac{1}{RW} \sum_{i=1}^{RW} P_0(i) \qquad\qquad \text{Equation 5}$$

$$mean\_peak_{LW} = \frac{1}{LW} \sum_{i=RW+GW+1}^{N} P_0(i) \qquad\qquad \text{Equation 6}$$

$$\Delta mean\_peak = mean\_peak_{RW} - mean\_peak_{LW} \qquad\qquad \text{Equation 7}$$

[0044]   Once the Δ mean peak value has been calculated, a threshold test is conducted (Step 704) to determine whether there is a fluctuation among peak powers within each window (LW and RW) and whether there is a change between the RW and LW windows, meaning a change from static to dynamic or dynamic to static channels within the sliding window. The threshold value is a predetermined value, preferably:

$$TH_{mean\_peak} = 3.0$$
$$TH\_Peak_{std,RW} = 1.0$$
$$TH\_Peak_{std,LW} = 1.0$$

$Th\_Peak_{std,RW}$ and $TH\_Peak_{std,LW}$ are thresholds which are related to the standard deviation (std) to detect a fluctuation of peak powers for fading channels. The threshold test compares the Δ mean peak values to the threshold and the peak values of the RW and LW to determine if there is a transition, meaning the channel within the LW is different than the channel within the RW, to determine if the channel within the LW is a static channel when the channel within the RW is a fading channel, and vice versa.

[0045] If the LW and RW channels are different and either one is static, the processor 111 sets the jump value SIR_{jump} based on the step_up and step_down counts of the jump process and computes the initial value of the target SIR static adjustment (adjStaticSIRdB) based on the delta mean and BLER (Step 705).

[0046] The jump value is set according to Equation 8a.

$$SIR_{jump} = SIR\_step\_up * step\_up\_count - SIR\_step\_down * step\_down\_count \quad \text{Equation 8a}$$

The initial value of adjStaticSIRdB, which is an adjustment value relative to an assumed reference dynamic channel, (preferably case 2), is set according to Equation 8b; where the BLER is mapped using the graphs shown Figure 4.

$$\text{adjStaticSIRdB} = -1.5 * \Delta\text{mean peak} * \log10(1.0/\text{BLER}) \quad \text{Equation 8b}$$

[0047] The initial value of adjStaticSIRdB is then modified based on the power ratio, depending on whether the RW channel is static or the LW channel that is static. If the RW channel is the static channel (and the LW channel is the fading channel), the adjStaticSIRdB is modified with the average power ratio of the LW (AvPrevChChar) according to the pseudo code and Equation 9 set forth below:

$$AvPrevChChar = 0;$$

$$for\,j = 1: sizeofLW$$

$$AvPrevChChar = AvPrevChChar + prevChChar(1, j + sizeofRW + maxsizeofGap - 1);$$

$$end$$

$$AvPrevChChar = AvPrevChChar\,/\,sizeofLW;$$

$$deltaMean = AvPrevChChar + 10.8;$$

$$adjStaticSIRdB = adjStaticSIRdB + 0.4 * deltaMean * log10(1.0\,/\,BLER). \qquad \text{Equation 9}$$

If the LW channel is the static channel (and the RW channel is the fading channel), the adjusted static SIR adjStaticSIRdB is calculated according to Equation 10:

$$adjStaticSIRdB = adjStaticSIRdB - 0.4 * delta\,mean * log10(1.0\,/\,BLER) \qquad \text{Equation 10}$$

where delta mean = 7.0.

[0048]   Once the initial static adjustment is re-calculated, a determination is made as to whether the adjustment is too large, which protects against making large adjustments at one time. This is accomplished by comparing the static adjustment to a maximum adjustment maxadjSIRdB, where

$$max\,adjSIRdB = 3 * log10(1\,/\,BLER). \qquad \text{Equation 11}$$

If the maximum is less than the calculated adjustment, the maximum value is utilized as the static adjustment. The processor 111 then adjusts the static adjustment in accordance with Equation 12:

$$adjStaticSIRdB = adjStaticSIRdB - SIRjump \qquad \text{Equation 12}$$

[0049]   Upon the calculation of the static adjustment, the processor 111 initializes the peak power, step_up and step_down counts, and power ratio for the new channel (Step 706). The initialization of the power ratio will set the reference channel to the case 2 assumed reference channel used in Equation 8b, to begin the second filter process. The initialization of the step_up and step_down counts will set Equation 8a to zero in the second filter process so that the SIR_{jump} adjustment is not used twice.

[0050]   If the threshold test is not passed (i.e., a change between the RW and LW windows is not detected) and the gap size is less than the maximum gap size, the processor 111 increases the gap size by one (1) (Step 708) and the peak values of the LW and RW and Δ mean are recalculated (Step 703). If the GW is at the predetermined maximum, the processor 111 moves the sliding window and begins the next observation period OP₁ (Step 707).

[0051]   As stated above, the processor 111 sequentially conducts the second filter process 800 to generate a dynamic (fading) channel adjustment. The second filter process 800 characterizes fading channel conditions by using a power ratio of multipaths. The flow diagram of the second filtering process 800 is illustrated in Figure 8. When the first filter process 700 is initially run, the values in the LW and RW of the first filter are accumulated by the observed/measured peak powers, while the values in the LW of the second filter process 800 are predetermined by the power ratios of the assumed plausible channel condition, for example case 1, and the values in the GW and RW of the second filter process 800 are accumulated by the observed/measured power ratios. Once the RW has accumulated an observations O₂ worth of data, the power ratio within that observation O₂ is determined. Those predetermined power ratio values within the LW and any second or third observed/measured value within RW are used by the processor 111 to determine the adjustment value.

[0052]   Similar to the first filter process 700, the second filter process 800 computes the mean difference of the LW and RW power ratio values computed in each. As stated earlier, the sliding window for the second filter process 800 comprises a LW, RW and GW, which can be of any predetermined length (Step 803). The power ratio for each observation in each window is computed according to Equation 13 below:

$$P_{10}(i) = \frac{1}{N_{obs}} \sum^{N_{obs}} 10 * [\log 10(P_1(j)) - \log 10(P_0(j))] \qquad \text{Equation 13}$$

where N_{obs} is the number of samples per observation period OP₂, P₀(j) is the power of the strongest path and P₁(j) is the power of the second strongest path.

[0053]   The mean power ratios and the delta mean (Δmean) are then calculated in accordance with equations 14, 15 and 16 below:

$$mean_{RW} = \frac{1}{RW} \sum_{i=1}^{RW} P_{10}(i)$$

Equation 14

$$mean_{LW} = \frac{1}{LW} \sum_{i=RW+GW+1}^{N} P_{10}(i)$$

Equation 15

$$\Delta mean = mean_{RW} - mean_{LW}$$

Equation 16

[0054]   Similar to the first filter process 700, threshold values are generated and the mean and power ratios of the RW and LW are compared to the threshold (Step 804). The threshold values are computed in accordance with the following pseudo-code:

$if\,((mean_{LW} > -7.0)\,\&\,(mean_{RW} > -7.0))$

$\quad TH_{mean} = 2.0;$

$\quad TH_{std,LW} = abs(0.35 * \Delta mean);$

$\quad TH_{std,RW} = abs(0.5 * \Delta mean);$

$else$

$\quad TH_{mean} = 3.0;$

$\quad TH_{std,LW} = abs(0.3 * \Delta mean);$

$\quad TH_{std,RW} = abs(0.5 * 0.3 * \Delta mean);$

$\quad End$

where -7.0 represents the fading channel conditions that have weak second path or no second path.

[0055]   If the mean difference and the power ratio values of the RW and LW are within the threshold range, the processor 111 sets the SIR$_{jump}$ and an initial fading channel SIR adjustment (Step 805) according to Equations 17 and 18, below:

$$SIR_{jump} = SIR\_step\_up * step\_up\_count - SIR\_step\_down * step\_down\_count$$ Equation 17

$$SIR_{target}^{adj} = a * \Delta mean * \log 10(1/BLER)$$

Equation 18

where the BLER is again mapped from the assumed reference channel.

[0056]   If the initial SIR_{target}^{adj} is greater than a maximum adjustment,

$$\max adjSIRdB = 3 * \log 10(1 / BLER) \hspace{2cm} \text{Equation 19}$$

then the SIR_{target}^{adj} is set to maxadjSIRdB. The processor 111 then adjusts the initial or

maximum adjustment SIR_{target}^{adj} by SIR$_{jump}$:

$$SIR_{target}^{adj} = SIR_{target}^{adj} - SIR_{jump} \hspace{2cm} \text{Equation 20}$$

The SIR_{target}^{adj} presents a fading channel adjustment to the assumed reference channel.

For example, if the assumed reference channel is case 2 and the actual channel

condition is a case 3 channel, the SIR_{target}^{adj} adjusts the static adjustment generated by the

first filter process 700 to reduce or increase the static adjustment value so that the

target SIR sent to the base station represents actual channel conditions of the case 3

channel.

[0057]   If the threshold test is not passed, the second filter process operates

similar to the first filter process in that the gap size is incremented by one (1) (Step

808) if it is not greater than or equal to the maximum gap size, or the sliding window

moves by one step forward for the next observation period (Step 807) and the SIR_{target}^{adj} is

set to 0.

[0058]   Each time an observation is completed for the first and/or second filter

process, the SIR$_{Target}$ is determined according to Equation 21, below:

$$target\_SIR(k) = target\_SIR(k-1) + adjstaticSIRdB + SIR_{target}^{adj} \hspace{1cm} \text{Equation 21}$$

[0059]   The processor 111 determines the adjustment of the base station transmit

power by comparing the measured SIR with the SIR$_{Target}$. Using this comparison, a

TPC command is subsequently sent to the base station 80.

[0060]   Referring to Figure 3B, the base station 80 comprises, an antenna 82, an

isolator or switch 84, a demodulator 86, a channel estimation device 88, a data

estimation device 90, processor 103, a transmission power calculation device 98, a data

generator 102, an encoder 110, an insertion device 104 and a modulator 106. The

antenna 82 or, alternately, antenna array of the base station 30$_1$ receives various RF

signals including the TPC command. The received signals are passed via a switch 84 to a demodulator 86 to produce a baseband signal. Alternatively separate antennas may be used for transmit or receive functions. The baseband signal is processed, such as by a channel estimation device 88 and a data estimation device 90, in the time slots and with the appropriate codes assigned to the communication burst of the UE 22. The channel estimation device 88 uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses. The channel information is used by the data estimation device 90. The data information is provided to the transmit power calculation device 98 by processor 103.

[0061]   Processor 103 converts the soft symbols produced by the data estimation device 90 to bits and extracts the TPC command associated with the CCTrCH. The transmit power calculation device 98 increases or decreases the transmission power for the CCTrCH by the predetermined step size according to the TPC command.

[0062]   Data to be transmitted from the base station 30_1 is produced by data generator 102.   The data is error detection/correction encoded by error detection/correction encoder 110.   The error encoded data is spread and time-multiplexed with a training sequence by the training sequence insertion device 104 in the appropriate time slot(s) and code(s) of the assigned physical channels, producing a communication burst(s).   The spread signal is amplified by an amplifier 106 and modulated by modulator 108 to radio frequency. The gain of the amplifier is controlled by the transmit power calculation device 98 to achieve the determined transmission power level for each time slot. The power controlled communication burst(s) is passed through the isolator 84 and radiated by the antenna 82.

[0063]   The flow diagram of the channel-adaptive downlink outer-loop power control algorithm of the present invention is illustrated in Figure 9. A target BLER is communicated to the receiver 10 from the base station 30, (Step 901). Using the received target BLER, a target SIR is obtained for a given channel (Step 902) and the step_up and step_down sizes for the jump algorithm are calculated (Step 903). The

step_up and step_down counters are initialized and the parameters for the first and second filter processes are set (i.e., observation periods) (Step 904).

[0064]   If the receiver 10 is synchronized with the base station and there is no discontinuation of transmission (DTX), the jump algorithm is conducted by the processor 111 (Step 905). Upon the generation of the SIR_{Target} by the jump algorithm, the processor 111 conducts the first filter process (Step 906) to generate a static adjustment value. Once the first filter process has accumulated enough observations to fill the first sliding window, the process calculates the peak power (Step 907) and generates the static SIR adjustment (Step 908). The processor 111 then conducts the second filter process (step 909). The power ratios are calculated for each observation O_2 within the second filter window (step 910) and generates the fading channel adjustment (Step 911). The SIR_{Target} is then adjusted according to the adjustment values generated by the first and second filter processes respectively 700, 800 (Step 912).

[0065]   The downlink outer loop power control algorithm, in accordance with the preferred embodiment of the present invention utilizes a jump algorithm and a channel-adaptive algorithm to mitigate the channel error and adapts to the time-varying channel conditions. If the channel-adaptive algorithm uses more samples of P0 and P1/P0 per frame or uses PCCPCH of SCH prior to the TPC, it could shorten the convergence time. Hence the channel-adaptive outer-loop power control algorithm will meet the desirable convergence time and reduce the battery power consumption in the uplink TPC and interference in the downlink TPC (results in more capacity). The channel-adaptive algorithm can be extended by adding more features, P2/P0, P3/P0, the number of multi-paths, etc. to improve performance. Since the algorithm is general, it can be applied to the uplink TPC of TDD and the uplink/downlink TPC of FDD.

[0066]   While the present invention has been described in terms of the preferred embodiment, other variations which are within the scope of the invention as outlined in the claims below will be apparent to those skilled in the art.

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